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INTERNATIONAL TRADE TRANSMISSION CHANNEL OF A LOCAL CRISIS: A SIMPLE MODEL

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RESUMEN

Clasificación JEL: F10, F15, F41, F42.

Proponemos un modelo de interdependencia general lineal para la economía mundial, y utilizamos datos de la División Estadística de las Naciones Unidas para estimar sus parámetros. Esto nos permite evaluar la propagación de un *shock* exógeno a los gastos autónomos de un país mediante el canal del comercio internacional, pudiendo construir un "ranking de vulnerabilidad" para los países de la muestra frente a un *shock* a cualquiera de ellos. La respuesta del sistema a un *shock* negativo sobre los gastos autónomos de Estados Unidos es llevado a cabo como ejemplo. Si bien sujeto a múltiples debilidades, estos resultados de estática comparativa pueden ser útiles para análisis de política.

Palabras clave: Multiplicador de comercio mundial, Modelos lineales de interdependencia general, Analisis Insumo-Producto, Desacople.

ABSTRACT

JEL Classification: F10, F15, F41, F42.

We propose a linear general interdependence model of the world economy, and use United Nations Statistics Division data to estimate its parameters. This allows us to assess the propagation through the channel of international trade of an exogenous shock to one country's autonomous expenditures, thereby constructing a "vulnerability ranking" for the countries in the sample to an exogenous shock to any of them. The response of the system to a negative shock to the United States autonomous outlays is carried out as an example. Though subject to multiple caveats, these comparative statics results might be useful for policy analysis.

Keywords: World trade multiplier, Linear general interdependence models, Input-Output analysis, Decoupling.

INTERNATIONAL TRADE TRANSMISSION CHANNEL OF A LOCAL CRISIS: A SIMPLE MODEL[1]

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I. Introduction

The recent financial crisis in the United States (US) gave rise to the question of how a real downturn in that economy could affect economies around the globe. In particular, it was suggested that many developing countries could be considered "decoupled," in that their dependence on the US economy is negligible. However, the fact that US trade deficit represents 60% (in 2006) of the overall deficit of the economies with negative goods trade balance casts doubt on such conjectures. Whether directly or indirectly, it seems reasonable to expect that the behaviour of such a large economy affects the economic performance of the rest of the world in a nontrivial way.

An approximate but quantitative answer to this question requires to account for the interdependences of production and expenditure between all the economies of the world. In this sense, a world matrix of international trade, together with national accounts aggregates, seems a natural place to look for answers. In this paper we propose a simple linear general interdependence model of the world economy which arises from the interrelations observed in the world trade matrix.

With the aim of addressing these issues, section II develops a model for the simultaneous determination of income levels for a set of *n* countries considered altogether. Section III presents the data sources, and, after a brief discussion on the appropriate identification strategy, obtains point estimates for the parameters of the model. Section IV proceeds using these results in an

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exercise intended to assess the propagation through international trade of an exogenous shock to US autonomous outlays. Section V relates our study to the existing literature on the subject. Section VI contains both concluding remarks and directions for future research.

II. A Simple Representation of the World Economy

While interindustry flows *between* sectors *within* a country are a common use of Input-Output techniques, the analyses of world trade interdependencies are not so frequent. However, as national accounting principles state that one country's exports are another country's imports, mutual interactions between countries (either at an aggregate or sectoral level) conform trade relations that can be systematized as interdependence relations. Pioneering work in this field has been done by Metzler (1950), which is the model that we follow most closely.

We begin by decomposing aggregate expenditure in household consumption and fixed investment alongside exports of *goods* for a set of n countries. Let Y_i, C_i, I_i, X_i and M_i be gross domestic product (GDP), final household consumption, gross fixed capital formation, exports and imports of *goods* of country i, respectively. Then, the following national accounts identity holds in each country:

$$Y_i \equiv C_i + I_i + X_i - M_i + J_i \tag{1}$$

where J_i represents changes in inventories, government expenditure, net balance of foreign trade in *services*, and errors and omissions in data. As the exports[3] of country i are the imports of other countries, it is true that $X_i \equiv M_{i1} + \ldots + M_{in}$, where M_{i1} stands for the value of exports from country i to country 1, i.e. the imports of country 1 from country i.

By assuming proper behaviour for the components of aggregate demand systematically related to GDP it is possible to construct a model for the simultaneous determination of the levels of income for all countries. We shall propose the following simple behavioural functions for C_i, I_i and M_{ji}:

$$C_i(Y_i) = c_i(Y_i) + C_i^0 \tag{2}$$

[3] Due to the difficulties in obtaining bilateral trade data of services, from now on we will speak of exports and imports referring to foreign trade of goods, exclusively. Therefore, we take the net trade balance of services for each country as given, and include it in the term J_i.

$$I_i(Y_i) = i_i(Y_i) + I_i^0 \tag{3}$$

$$M_{ji}(Y_i) = m_{ji}(Y_i) + M_{ji}^0 \tag{4}$$

i.e. for each variable in country *i*, its determination depends on a part systematically related to current GDP and another part that is autonomous within the system.

All over the text we will employ the terms *induced* and *autonomous* expenditures. By autonomous, in the context of this paper, we will refer to an outlay that is not systematically related to the level of GDP/domestic income. But, of course, these expenditures could be induced by other variables not considered as endogenous in this framework.

It is of special importance the role of $m_{ji}(Y_i)$ in equation (4). It connects trade relations among countries when it is incorporated in the accounting identity for X_i:

$$X_i(Y_1,\ldots,Y_n) = m_{i1}(Y_1) + \ldots + m_{in}(Y_n) + M_{i\bullet}^0 \tag{5}$$

$$M_i(Y_i) = m_i(Y_i) + M_{\bullet i}^0 \tag{6}$$

$$m_i(Y_i) = m_{1i}(Y_i) + \ldots m_{ni}(Y_n) \tag{7}$$

where $M_{i\cdot}^0 \equiv M_{i1}^0 + \ldots + M_{in}^0$ and $M_{\cdot i}^0 \equiv M_{1i}^0 + \ldots + M_{ni}^0$ are the exports and imports of goods of country *i* not systematically related to GDP, respectively. In this sense, our model will not strictly be an Input-Output model, as our import requirement coefficients per unit of GDP will be marginal, so part of world trade will necessarily be treated as autonomous. Replacing (2), (3), (5) and (6) on the accounting identity (1) we obtain the following equilibrium condition for country *i*:

$$Y_i = c_i(Y_i) + i_i(Y_i) - m_i(Y_i) + m_{i1}(Y_1) + \ldots + m_{in}(Y_n) + A_i^0 \tag{8}$$

where $A_i^0 = J_i + C_i^0 + I_i^0 + M_{i\cdot}^0 - M_{\cdot i}^0$ represents all autonomous components not systematically related to GDP in the model.

According to the model, a fall in income leads inevitably to decreases in consumption and investment. Thus, the capital market plays no role in the adjustment process of a given country in the event of a fall in its income, for instance, when its exports fall. For the purposes of this paper, however, this strong assumption might be appropriate, since it is the *trade* channel of international transmission that we are interested in. Moreover, as long as we are considering situations of global GDP contraction, it is plausible to think of the existence of some constraints on the credit market.

Furthermore, the equation for imports (7) has an important consequence when the world as whole is considered. In particular, it is assumed that the part of the supply of exports systematically related to GDP is perfectly elastic, their level depending only on the demand of the rest of the world. This makes the autonomous part of exports ($M_{i\cdot}^0$) to account for situations where exports are induced locally. In other words, there is no endogenous behaviour for the "conquering" of new markets from a single country's perspective. An analogous case can be made for imports. Transnationalization of production implies that it is conceivable that a country's imports partially depend on the income of the rest of the world, as long as imports are inputs to the production of exports. This is necessarily the case for countries such as Singapore, where imports in 2006 represented 221% of GDP.

For the empirical implementation of the model we will assume constant marginal propensities in all the relevant variables. This implies that $c_i(Y_i)=c_iY_i$, $i_i(Y_i)=i_iY_i$, $m_i(Y_i)=m_iY_i$ and $m_{ji}(Y_i)=m_{ji}Y_i$ for $i = 1...n$ and $i\neq j$. Therefore, the system of equations (8) can be formulated as:

$$\begin{aligned} Y_1 &= c_1Y_1 + i_1Y_1 - m_1Y_1 + m_{12}Y_2 + \ldots + m_{1n}Y_n + A_1^0 \\ Y_2 &= c_2Y_2 + i_2Y_2 - m_2Y_2 + m_{21}Y_1 + \ldots + m_{2n}Y_n + A_2^0 \\ &\vdots \\ Y_n &= c_nY_n + i_nY_n - m_nY_n + m_{n1}Y_1 + \ldots + m_{n(n-1)}Y_{n(n-1)} + A_n^0 \end{aligned} \tag{9}$$

In matrix form we obtain:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} = \underbrace{\begin{bmatrix} g_1 - m_1 & m_{12} & \cdots & m_{1n} \\ m_{21} & g_2 - m_2 & \cdots & m_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1} & m_{n2} & \cdots & g_n - m_n \end{bmatrix}}_{\mathbf{H}} \begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix} + \begin{bmatrix} A_1^0 \\ A_2^0 \\ \vdots \\ A_n^0 \end{bmatrix} \tag{10}$$

where $g_i = c_i + i_i$ is the marginal propensity to spend in household consumption and invest in fixed capital out of GDP for country i and **H** is a matrix of coefficients where $h_{ij} = m_{ij}$ captures the marginal propensity to import of country j from country i and $h_{ii} = g_i - m_i$ captures the consumption, investment and import marginal propensities per unit of product of country i.

In order to complete our specification, we need to define the relationship between m_i and m_{1i} + ... + m_{ni} found in equation (7). As our objective is to reflect the endogenous *marginal* responses of the system to an exogenous shock to the *present* pattern of trade, we will assume that each country's marginal propensity to import is divided among its trading partners according to the current participation each seller has in total imports of country *i*. Therefore, we shall get:

$$m_i(Y_i) = m_{1i}(Y_i) + \ldots + m_{ni}(Y_i) = \alpha_{1i} m_i Y_i + \ldots + \alpha_{ni} m_i Y_i = (\alpha_{1i} + \ldots + \alpha_{ni}) m_i Y_i \quad (11)$$

where $\alpha_{ji} = M_{ji}/M_i$, and necessarily α_{1i} + ... + α_{ni} = 1.

In this case, the matrix of foreign trade interdependencies (obtained by considering the off-diagonal elements of **H**) can now be formulated as:

$$\begin{bmatrix} 0 & m_{12} & \cdots & m_{1n} \\ m_{21} & 0 & \cdots & m_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1} & m_{n2} & \cdots & 0 \end{bmatrix} = \begin{bmatrix} 0 & \alpha_{12} & \cdots & \alpha_{1n} \\ \alpha_{21} & 0 & \cdots & \alpha_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_{n1} & \alpha_{n2} & \cdots & 0 \end{bmatrix} \begin{bmatrix} m_1 & 0 & \cdots & 0 \\ 0 & m_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & m_n \end{bmatrix} \quad (12)$$

By introducing (12) in (10), and making simple matrix operations to decompose the parts of **H** it is possible to obtain an expression for the autonomous components of the system in terms of those components systematically related to GDP:

$$\underbrace{\begin{bmatrix} A_1^0 \\ A_2^0 \\ \vdots \\ A_n^0 \end{bmatrix}}_{\mathbf{A}} = \left(\mathbf{I} - \left[\underbrace{\begin{bmatrix} g_1 & 0 & \cdots & 0 \\ 0 & g_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & g_n \end{bmatrix}}_{\hat{\mathbf{g}}} - \left(\mathbf{I} - \underbrace{\begin{bmatrix} 0 & \alpha_{12} & \cdots & \alpha_{1n} \\ \alpha_{21} & 0 & \cdots & \alpha_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \alpha_{n1} & \alpha_{n2} & \cdots & 0 \end{bmatrix}}_{\Lambda} \right) \underbrace{\begin{bmatrix} 0 & m_{12} & \cdots & m_{1n} \\ m_{21} & 0 & \cdots & m_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ m_{n1} & m_{n2} & \cdots & 0 \end{bmatrix}}_{\hat{\mathbf{m}}} \right] \right) \underbrace{\begin{bmatrix} Y_1 \\ Y_2 \\ \vdots \\ Y_n \end{bmatrix}}_{\mathbf{Y}}$$

where **I** is an *n*x*n* identity matrix, **A** is a *n*x1 vector of components not systematically related to GDP, **Y** is a *n*x1 vector of GDP for the *n* countries, $\hat{\mathbf{g}}$ and $\hat{\mathbf{m}}$ are *n*x*n* diagonal matrices of *n*x1 vectors $\mathbf{g}=(g_1,\ldots,g_n)'$ and $\mathbf{m}=(m_1,\ldots,m_n)'$, respectively. Therefore, the main matrix equation for our linear system is:

$$\mathbf{A} = (\mathbf{I} - [\hat{\mathbf{g}} - (\mathbf{I} - \Lambda)\hat{\mathbf{m}}])\mathbf{Y} = (\mathbf{I} - \mathbf{H})\mathbf{Y} \quad (13)$$

where $\mathbf{H} = \hat{\mathbf{g}} - (\mathbf{I} - \mathbf{\Lambda})\hat{\mathbf{m}}$ captures consumption and investment marginal propensities (in $\hat{\mathbf{g}}$), as well as trade interdependences among countries (in $\hat{\mathbf{m}}$ and $\mathbf{\Lambda}$).

In order for (**I - H**) to admit an inverse, it is necessary that *det*(**I - H**)≠0. Essentially, this is the requirement for the non-homogenous system (9) to admit a nontrivial solution.

In this case, we shall obtain the required GDP in each country for a given vector of autonomous components (**A**) by solving the linear system (13) for **Y**:

$$\mathbf{Y} = (\mathbf{I} - [\hat{\mathbf{g}} - (\mathbf{I} - \mathbf{\Lambda})\hat{\mathbf{m}}])^{-1}\mathbf{A} \tag{14}$$

It is possible to see equation (14) as the result of the *multiplying process* in the model. While $\hat{\mathbf{g}}$ accounts for the induced effects of consumption and investment on income, $(\mathbf{I} - \mathbf{\Lambda})\hat{\mathbf{m}}$ accounts for import leakages $(\mathbf{I}\hat{\mathbf{m}})$ and foreign trade direct and *indirect* effects $(\mathbf{\Lambda}\hat{\mathbf{m}})$.

The concept of multiplier arises as an endogenous response to exogenous outlays. To see this, assume that the constant marginal propensities of **H** in (10) represent coefficients of expenditure per unit of product of country *i* and import requirements from country *j* per unit of product of country *i*. By considering the accounting principle by which each source of expenditure equals the value of production supporting it, we obtain system (10):

$$\mathbf{Y} = \mathbf{H}\mathbf{Y} + \mathbf{A} \tag{15}$$

From (15) it is possible to obtain a solution for **Y** by recursive substitution:

$$\begin{aligned}
&\mathbf{Y} = \mathbf{H}\mathbf{Y} + \mathbf{A}\\
&\mathbf{Y} = \mathbf{H}(\mathbf{H}\mathbf{Y} + \mathbf{A}) + \mathbf{A} = \mathbf{H}^2\mathbf{Y} + \mathbf{H}\mathbf{A} + \mathbf{I}\mathbf{A}\\
&\vdots\\
&\mathbf{Y} = \mathbf{H}^n\mathbf{Y} + \mathbf{H}^{n-1}\mathbf{A} + \mathbf{H}^{n-2}\mathbf{A} + \ldots + \mathbf{H}\mathbf{A} + \mathbf{I}\mathbf{A}\\
&\mathbf{Y} = \mathbf{H}^n\mathbf{Y} + (\mathbf{I} + \mathbf{H} + \mathbf{H}^2 + \ldots + \mathbf{H}^{n-1})\mathbf{A}
\end{aligned} \tag{16}$$

so that

$$(\mathbf{I} - \mathbf{H})^n\mathbf{Y} = (\mathbf{I} + \mathbf{H} + \mathbf{H}^2 + \ldots + \mathbf{H}^{n-1})\mathbf{A} \tag{17}$$

We will work under the following condition.

Condition 1 $\mathbf{H}^n \to \mathbf{0}$ *as* $n \to \infty$.

Under Condition 1, as $n \to \infty$ (17) becomes

$$\mathbf{Y} = (\mathbf{I} - \mathbf{H})^{-1}\mathbf{A} \tag{18}$$

which is exactly the result obtained in (14) (see Appendix). In each successive substitution in (16), another round of indirect import requirements and induced expenditures takes place. The total effect is condensed in the solution (18).

Necessary and sufficient for condition 1 to hold is that the spectral radius of **H** be strictly smaller than one. That is, that the eigenvalue of **H** that is the greatest of all in absolute value be, in absolute value, strictly smaller than one[4]. The reason is that the absolute value of this eigenvalue sets the infimum of all possible norms of **H**, and $\mathbf{H}^n \rightarrow \mathbf{0}$ as $n \rightarrow \infty$ whenever at least one of its possible norms is strictly smaller than one[5]. If this is the case, then we can decompose the total effect summarized in (14) in the successive trade rounds of (16).

Given that (18) is a linear system, we propose to study what are the direct and indirect effects of a *change* in autonomous components **A** in the GDP vector **Y**:

$$\Delta\mathbf{Y} = (\mathbf{I} - \mathbf{H})^{-1}\Delta\mathbf{A} \tag{19}$$

The focus on the demand-side of GDP must be taken into consideration when doing exercises as the one proposed in equation (19). Since we are omitting any supply-side considerations, a proper use of the latter involves selecting $\Delta\mathbf{A} < 0$. In other words, the model as it is presented here should be preferably used to analyze contractions.

The proposed comparative statics exercise can be criticized on several grounds. As is customary, it must be noted that the coefficients that will be obtained in the next section depend on the particular configuration of the system in the sample used to estimate them. In particular, prices, exchange rates, trade patterns, propensities and autonomous expenditures must change as a response to exogenous impulses to the system. In our exercise, however, we heroically rule out these endogenous responses observed in real economies, allowing for the system to adjust solely through variation in the only quantities assumed endogenous, that is, individual incomes.

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[4] More simply stated, all eigenvalues must lie within the unit circle.

[5] See http://www.dm.uba.ar/materias/elementos_calculo_numerico_M/2008/2/apunte.pdf, pp. 44-45, especially Theorem 3.4 and Corollary 3.5 (in Spanish).

III. Data and Estimation

Data on commodity trade by origin and destination are available for 143 countries from the United Nations Commodity Trade Statistics Database (COMTRADE) for 2005[6]. Moreover, national accounts aggregates for these economies for the period 1970-2006 were also obtained from the United Nations Statistics Division. Linear probability models were estimated using the R statistical computing language and all systems of matrix algebra were solved using the Ox Programming Language.

In estimating the behavioural equations for consumption, investment and imports, we begin by identifying the marginal propensities in each relation. Once this is achieved, and a point estimation obtained, autonomous outlays will be calculated so as to match the observed GDP in the corresponding country. These outlays will include all components represented by vector **A** in equation (8).

Interpreting each of the behavioural equations of the previous section as a linear probability model, we obtain:

$$C_{i,t} = c_i^0 + c_i Y_{i,t} + v_{i,t}^c \quad (20)$$

$$I_{i,t} = i_i^0 + i_i Y_{i,t} + v_{i,t}^i \quad (21)$$

$$M_{i,t} = m_i^0 + m_i Y_{i,t} + v_{i,t}^m \quad (22)$$

where c_j^0, i_j^0 and m_j^0 are autonomous consumption, investment and imports and c_j, i_j and m_j are the marginal propensities to consume, invest and import, respectively. The perturbation terms v^c, v^i and v^m are assumed to be white noise processes, adding random variability to each relation.

As was early noted in the literature (Haavelmo (1947)), the imposition of the national accounts identity on any of the behavioural equations of the previous section raises a simultaneity issue. For instance, a shock $v_{j,t}^c$ will affect the level of consumption in period t. However, since consumption is one of the components of income, this shock will affect the latter (by the same amount). Hence, in equation (20) $Y_{j,t}$ is endogenous, and, in principle, c_j is not identified.

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[6] From the original sample consisting of 176 countries, 32 countries did not report trade statistics in 2005, and were therefore excluded from the analysis. Timor-Leste was also excluded on the grounds of unreliability of its data, exhibiting negative exports for several years.

Being predetermined in equations (20)-(22), lagged GDP captures a portion of the variability of current GDP that is, in principle, orthogonal to contemporaneous shocks to consumption[7]. A similar reasoning leads to the inclusion of a linear deterministic trend in the first stage of our instrumental variables estimation.

Three comments are in order regarding our identification strategy. First, this strategy will not be affected if, for some or all of the countries in the sample, dollar denominated GDP also exhibits a stochastic trend[8]. The presence of a unit root in dollar denominated GDP would invalidate traditional inference in the first step of our instrumental variables procedure. However, the least squares estimator would still be consistent (cf., for example, Hayashi (2000)).

Second, we can briefly address the effects of working with current US dollar denominated variables. A devaluation of the local currency of a country in a given period t will induce variability of current income and consumption. This variability, however, is not captured by $Y_{j,t-1}$, and, as a consequence, our instrument becomes *weaker*. Note, however, that consistency is not affected.

Finally, and most important, if the error terms in equations (20)-(22) are autorregresive of order $p \geq 1$, then the instrument lagged GDP fails to comply with the requirement of being orthogonal to these shocks. The reason is straightforward: since $v_{i,t-1}$ directly affects $Y_{i,t-1}$, then any systematic relation between $v_{i,t-1}$ and $v_{i,t}$ necessarily implies a systematic relation between $Y_{i,t-1}$ and $v_{i,t}$. Unfortunately, this is likely to be the case. As a result, the estimated marginal propensities used below are upward biased (see, for instance, Wooldridge (2002)).

The point estimates obtained by this instrumental variables procedure allow us to construct the diagonal matrices $\hat{\mathbf{g}}$ and $\hat{\mathbf{m}}$ in equation (14). In the case of

[7] The results when $Y_{j,t-2}$ and $Y_{j,t-3}$ are included as instruments as well did not alter our estimates significatively, and are available from the authors upon request.

[8] Whether nominal GDP has a stochastic trend or not seems to remain an open question. Using the original Nelson and Plosser (1982) data set, Pascalau (2008) employs two tests that are robust to Perron's (Perron (1989)) critique regarding the potential effects of structural breaks and Zivot and Andrews (1992) remark regarding the selection of the break date. The author supports the case of Nelson and Plosser, in the sense that nominal GDP in the United States exhibits a stochastic trend.

matrix $\hat{\mathbf{g}}$, its g_jth. element consists of the sum of the marginal propensities to consume and to invest $c_j + i_j$[9].

Table 1 displays the estimated coefficients representing marginal propensities to consume, invest in fixed capital and import for each country in the sample for the period 1970-2006.

Table 1. Point estimates for Marginal Propensities

UN ISO3	Country	$\hat{c}_i$	$\hat{i}_i$	$\hat{m}_i$
ALB	Albania	0.59	0.57	0.52
ARB	Aruba	0.53	0.28	0.73
ARE	United Arab Emirates	0.46	0.22	0.63
ARG	Argentina	0.68	0.17	0.13
ARM	Armenia	0.67	0.35	0.29
ATG	Antigua and Barbuda	0.33	0.53	0.74
AUS	Australia	0.58	0.25	0.23
AUT	Austria	0.56	0.21	0.47
AZE	Azerbaijan	0.27	0.39	0.44
BDI	Burundi	0.77	0.18	0.24
BEL	Belgium	0.53	0.19	0.83
BEN	Benin	0.78	0.19	0.26
BGR	Bulgaria	0.65	0.29	0.73
BHR	Bahrain	0.36	0.17	0.6
BIH	Bosnia and Herz.	0.83	0.18	0.48
BLR	Belarus	0.48	0.3	0.63
BLZ	Belize	0.77	0.2	0.66
BOL	Bolivia	0.74	0.15	0.3
BRA	Brazil	0.58	0.18	0.12
BRB	Barbados	0.66	0.18	0.55
BWA	Botswana	0.28	0.25	0.33
CAF	Central African Rep.	0.9	0.07	0.17
CAN	Canada	0.57	0.2	0.38
CHE	Switzerland	0.6	0.21	0.39
CHL	Chile	0.59	0.22	0.32
CHN	China	0.38	0.42	0.31
CIV	Cte d'Ivoire	0.7	0.06	0.33
CMR	Cameroon	0.69	0.2	0.17
COK	Cook Islands	0.5	0.1	0.6

[9] The same result is obtained if cj and ij are estimated altogether, by considering equations (20) and (21) as one equation only, with ($c_j + i_j$) being the marginal propensity to spend in household consumption and invest in fixed capital. The reason that we preferred not to proceed this way is that it is easier to analize the coefficients separately.

UN ISO3	**Country**	$\hat{c}_i$	$\hat{i}_i$	$\hat{m}_i$
COL	Colombia	0.63	0.18	0.23
CPV	Cape Verde	0.8	0.35	0.51
CRI	Costa Rica	0.64	0.19	0.53
CYP	Cyprus	0.64	0.17	0.51
CZE	Czech Republic	0.49	0.24	0.8
DEU	Germany	0.58	0.19	0.33
DMA	Dominica	0.66	0.27	0.63
DNK	Denmark	0.47	0.2	0.42
DZA	Algeria	0.38	0.22	0.2
ECU	Ecuador	0.68	0.21	0.31
EGY	Egypt	0.78	0.15	0.25
ESP	Spain	0.57	0.28	0.32
EST	Estonia	0.53	0.35	0.98
ETH	Ethiopia	0.8	0.16	0.31
FIN	Finland	0.51	0.17	0.33
FJI	Fiji	0.77	0.18	0.74
FRA	France	0.57	0.18	0.27
GAB	Gabon	0.39	0.17	0.29
GBR	United Kingdom	0.66	0.16	0.31
GEO	Georgia	0.52	0.31	0.64
GHA	Ghana	0.78	0.32	0.65
GMB	Gambia	0.73	0.29	0.64
GRC	Greece	0.71	0.22	0.28
GRD	Grenada	0.65	0.47	0.71
GTM	Guatemala	0.87	0.19	0.42
GUY	Guyana	0.54	0.5	1.26
HKG	Hong Kong (China)	0.6	0.26	1.6
HND	Honduras	0.76	0.26	0.64
HRV	Croatia	0.52	0.39	0.54
HUN	Hungary	0.56	0.2	0.77
IDN	Indonesia	0.63	0.24	0.28
IND	India	0.56	0.28	0.24
IRL	Ireland	0.43	0.26	0.73
IRN	Iran	0.5	0.24	0.17
ISL	Iceland	0.59	0.25	0.43
ISR	Israel	0.55	0.18	0.39
ITA	Italy	0.59	0.19	0.25
JAM	Jamaica	0.73	0.33	0.6
JOR	Jordan	0.86	0.22	0.8
JPN	Japan	0.57	0.25	0.09
KAZ	Kazakhstan	0.41	0.31	0.42
KGZ	Kyrgyzstan	0.98	0.16	0.78
KIR	Kiribati	0.51	0.39	0.54

UN ISO3	Country	$\hat{c}_i$	$\hat{i}_i$	$\hat{m}_i$
KNA	Saint Kitts and Nevis	0.54	0.48	0.67
KOR	Republic of Korea	0.53	0.31	0.37
LCA	Saint Lucia	0.62	0.27	0.61
LKA	Sri Lanka	0.68	0.25	0.46
LTU	Lithuania	0.66	0.23	0.72
LUX	Luxembourg	0.39	0.21	1.37
LVA	Latvia	0.66	0.39	0.68
MAR	Morocco	0.58	0.27	0.35
MDA	Republic of Moldova	0.76	0.27	0.67
MDG	Madagascar	0.88	0.2	0.43
MDV	Maldives	0.32	0.41	0.84
MEX	Mexico	0.69	0.2	0.35
MKD	TFYR of Macedonia	0.89	0.19	0.96
MLT	Malta	0.64	0.21	0.87
MNG	Mongolia	0.47	0.32	0.74
MOZ	Mozambique	0.54	0.17	0.23
MRT	Mauritania	0.77	0.24	0.55
MSR	Montserrat	0.43	0.49	0.84
MUS	Mauritius	0.65	0.23	0.65
MWI	Malawi	1.02	0.06	0.51
MYS	Malaysia	0.42	0.26	1.06
NAM	Namibia	0.54	0.24	0.39
NCL	New Caledonia	0.56	0.24	0.25
NER	Niger	0.74	0.16	0.27
NIC	Nicaragua	0.79	0.3	0.58
NLD	Netherlands	0.48	0.2	0.63
NOR	Norway	0.42	0.17	0.27
NZL	New Zealand	0.6	0.22	0.31
OMN	Oman	0.46	0.15	0.42
PAK	Pakistan	0.78	0.17	0.21
PAN	Panama	0.62	0.18	0.55
PER	Peru	0.69	0.2	0.17
PHL	Philippines	0.73	0.17	0.61
POL	Poland	0.64	0.19	0.41
PRT	Portugal	0.64	0.22	0.38
PRY	Paraguay	0.77	0.19	0.58
PYF	French Polynesia	0.49	0.1	0.23
QAT	Qatar	0.16	0.32	0.3
ROM	Romania	0.69	0.23	0.45
RUS	Russian Federation	0.47	0.18	0.21
SAU	Saudi Arabia	0.32	0.17	0.28
SDN	Sudan	0.65	0.22	0.2
SEN	Senegal	0.75	0.26	0.37

UN ISO3	Country	$\hat{c}_i$	$\hat{i}_i$	$\hat{m}_i$
SGP	Singapore	0.42	0.28	1.79
SLV	El Salvador	0.94	0.16	0.45
STP	Sao Tome and Pr.	0.76	0.66	1.43
SUR	Suriname	0.2	0.82	0.51
SVK	Slovakia	0.59	0.26	0.93
SVN	Slovenia	0.53	0.29	0.69
SWE	Sweden	0.48	0.16	0.4
SWZ	Swaziland	0.64	0.17	0.97
SYC	Seychelles	0.56	0.25	0.91
SYR	Syrian Arab Republic	0.63	0.23	0.35
TCA	Turks and Caicos Is.	0.35	0.34	0.54
TGO	Togo	0.98	0.11	0.47
THA	Thailand	0.54	0.31	0.62
TTO	Trinidad and Tobago	0.48	0.18	0.41
TUN	Tunisia	0.63	0.23	0.52
TUR	Turkey	0.68	0.21	0.36
TZA	Tanzania	0.84	0.18	0.26
UGA	Uganda	0.79	0.27	0.33
UKR	Ukraine	0.54	0.27	0.33
URY	Uruguay	0.74	0.13	0.22
USA	United States	0.71	0.19	0.17
VCT	St. Vincent and the Gr.	0.65	0.32	0.64
VEN	Venezuela	0.56	0.17	0.18
VNM	Vietnam	0.63	0.34	0.73
YEM	Yemen	0.57	0.23	0.4
ZAF	South Africa	0.65	0.14	0.27
ZMB	Zambia	0.79	0.23	0.23
ZWE	Zimbabwe	0.61	0.24	0.29

Data Source: UNSTATS National Accounts Aggregates.

The fact that the point estimates of the marginal propensities to import for six countries (Guyana, Hong Kong (SAR of China), Luxembourg, Malaysia, Singapore and Sao Tome and Principe) are above unity may reflect either errors in data, or, most likely, the fact that imports do not depend only on domestic income, but, to the extent that they are used as inputs for the production of exports, also on world income. This aspect of trade is not encompassed by the model here proposed. On the other hand, only one propensity to consume is greater than one (Malawi)[10].

[10] We do not analyze the dynamic properties of the estimated model, mainly because it would be

As was already stated in the previous section, we are now interested in the introduction of the present pattern of trade into the analysis. Therefore, the matrix $\mathbf{\Lambda}$ in equation (14) is obtained by post-multiplying the transactions matrix of world trade **T** by the inverse of a diagonal matrix $\hat{\mathbf{d}}$, with element d_{jj} equal to the total imports of country j ($M_{\cdot j}$):

$$\mathbf{\Lambda} \equiv \mathbf{T}\hat{\mathbf{d}}^{-1} \qquad (23)$$

For the sake of exposition, we show the transactions matrix **T** for a limited group of countries. Dividing the 143 countries of our sample into 5 blocks: Africa, Asia and Oceania, Europe, Latin America and the Caribbean, and NAFTA (Mexico, Canada and the US), the matrix of commodity trade statistics for the year 2005 looks as follows:

Table 2. **World Trade Matrix Year 2005** (in millions of current US dollars).

Region	Africa	Asia-Ocean	Europe	LatAm-Car.	NAFTA	**Exports**
Africa	19,790.57	37,272.08	90,104.30	4,252.07	31,289.97	182,708.99
Asia-Ocean	60,180.19	1,791,928.04	822,265.51	49,843.60	774,697.74	3,498,915.08
Europe	80,277.16	533,705.97	2,857,463.27	46,920.39	417,140.87	3,935,507.66
LatAm-Car.	6,898.18	67,193.35	79,250.77	75,273.21	144,589.83	373,205.34
NAFTA	12,640.90	319,868.93	269,354.89	71,295.94	782,109.95	1,455,270.60
Imports	179,787.01	2,749,968.37	4,118,438.74	247,585.20	2,149,828.35	9,445,607.68
Balance	2,921.97	748,946.71	-182,931.07	125,620.13	-694,557.75	

Data Source: UNSTATS COMTRADE.

Each column of this matrix displays the imports of the corresponding block of countries by origin. Given that there exists trade within each of this blocks, the matrix has nonzero diagonal elements. The matrix **T** used in our calculations is conceptually identical to the one presented, with the only difference being its size, which is initially 143 × 143.

With our estimates of matrices $\hat{\mathbf{g}}$, $\hat{\mathbf{m}}$ and $\mathbf{\Lambda}$, we then proceed to check if condition 1 holds for the resulting estimated **H** matrix. As it turns out, when

difficult to claim that the initial position of the system, provided by the 2005 world trade pattern, is one of equilibrium. However, it might be worth noting that Metzler (Metzler (1950), p. 340) proves that marginal propensities to spend lower than one is a sufficient condition for stability using Samuelsons's well known correspondence principle. For 29 of the countries in the sample the sum of the propensities to consume and to invest is greater than one.

these 143 countries are considered altogether, the estimated matrix **H** has a spectral radius of 1.1557. When a manual check is done raising **H** to *n*, taking *n* to be successively larger powers, it is the row and column corresponding to Singapore, for which $g - m$ is smaller than -1, that produces this result. When Singapore is eliminated from the sample, the corresponding estimate of matrix **H** has a spectral radius of 0.8256. Although the results are not sensitive to this exclusion when a shock to the US economy is considered[11], a proper decomposition of total effects in several stages of a multiplying process motivated us to present the results for the 142-countries sample[12].

As a final remark, it should be noted that the initial value for the vector of autonomous outlays **A** is straightforwardly calculated using equation (13). That is, initial autonomous outlays are obtained so as to match 2005 GDP levels.

IV. Empirical exercise: Towards a "Vulnerability" Ranking

With the estimated values of $\hat{\mathbf{g}}$, $\hat{\mathbf{m}}$, and the 2005 pattern of world trade given by **Λ**, we then proceeded to construct the following vector of *changes* of autonomous components:

$$\Delta \mathbf{A}_{US} = \begin{bmatrix} 0 \\ \vdots \\ -0.1\mathbf{A}_{US}^{05} \\ 0 \\ \vdots \\ 0 \end{bmatrix}$$

where the only nonempty position is the one corresponding to the US. In this way, we aim to assess direct and *indirect* effects of a negative shock to US autonomous expenditures on the GDP vector **Y** for the n = 142 countries of our sample.

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[11] The results of the exercise of the next section when Singapore is included are available from the authors upon request.

[12] It is evident that the problem stems from having marginal propensities to import that are higher than one. To be closer to complying with some basic aspects of the phenomenon under study, we should strive for a more comprehensive treatment of the demand for imports. To a great extent, this amounts to accounting for the import content of exports.

Thus, by calculating $(\Delta\mathbf{Y})(\hat{\mathbf{Y}}^{-1}) = (\mathbf{I} - [\hat{\mathbf{g}} - (\mathbf{I} - \mathbf{\Lambda})\hat{\mathbf{m}}])^{-1}(\Delta\mathbf{A}_{US})(\hat{\mathbf{Y}}^{-1})$, we obtained the proportional change of income in each country with respect to its initial GDP level of 2005 due to a negative shock of 10% to the US autonomous outlays.

A simple illustration of the logic of the multiplier process beyond direct reductions in US GDP and import requirements proceeds as follows. The contraction in autonomous outlays reduces US GDP and activates the domestic multiplier (g_{us} in $\hat{\mathbf{g}}$) through its negative effect on induced consumption and investment. Therefore, as reduced income implies a reduction in demand for foreign goods, there will be a fall in US imports in proportion to its column distribution in $\mathbf{\Lambda}\hat{\mathbf{m}}$. Countries exporting to the US will face this immediate effect. Take, for example, the cases of Canada, China and Mexico, which represented 43.4% of US imports in 2005.

From these countries' perspective, this fall in exports represents a contraction in a non-induced (relative to *own* GDP) component of their income. As a consequence, their domestic multipliers will begin to operate with the corresponding negative effect on income levels. The overall fall in GDP of these US trade partners will, in turn, affect exports of those economies exporting to them. For instance, Japan and the European Union will suffer, as they represented in 2005 30.4% of China's imports. The argument follows *ad infinitum*.

While the final result of the subsequent trade and induced income effects is captured by $(\mathbf{I} - \mathbf{H})^{-1} = (\mathbf{I} - [\hat{\mathbf{g}} - (\mathbf{I} - \mathbf{\Lambda})\hat{\mathbf{m}}])^{-1}$, it is straightforward to see that the impacts of each round of national and international repercussions successively accumulate according to non-reduced forms $\Delta\mathbf{A} + \mathbf{H}\Delta\mathbf{A}$ for the first round, $\Delta\mathbf{A} + \mathbf{H}\Delta\mathbf{A} + \mathbf{H}(\mathbf{H}\Delta\mathbf{A})$ for the second round, and so on.

Table 3 summarizes the estimated impacts of the hypothetical US slowdown for the 142 countries of our sample, ranked by the negative total effects as a proportion of 2005 own GDP in each country (fifth column of the table). The last column of the table indicates the elasticity of each country's GDP to variations in US GDP.

As can be seen, the final effect on three of the economies considered (Aruba, Honduras and Trinidad and Tobago) is greater that that of the US. As was noted by Mundell ((1965), p. 350), income in countries other than the one suffering from the initial shock may fall proportionately more than the latter.

Table 3. Vulnerability Ranking of a 10% reduction in the US autonomous outlays

		Accumulated Effects (p.p. of own 2005 GDP)			% of Total Effect		
Rank	Country	1st.	2nd.	**Total**	1st.	5th./+	Elasticity
1	Aruba	-3.09%	-2.59%	-15.63%	19.78%	40.53%	2.04
2	Honduras	-1.08%	-1.24%	-8.32%	12.97%	47.52%	1.09
3	Trin. and Tobago	-1.27%	-1.32%	-8.32%	15.33%	44.54%	1.09
4	United States	-3.09%	-0.98%	-7.67%	40.36%	29.46%	1
5	Nicaragua	-0.58%	-0.78%	-6.58%	8.75%	55.89%	0.86
6	Venezuela	-0.57%	-0.76%	-6.19%	9.16%	54.94%	0.81
7	Gabon	-0.78%	-0.84%	-5.48%	14.28%	46.37%	0.71
8	Ecuador	-0.39%	-0.55%	-5.30%	7.41%	60.81%	0.69
9	Mexico	-0.52%	-0.68%	-5.23%	9.89%	52.86%	0.68
10	Zimbabwe	-0.10%	-0.22%	-5.04%	2.02%	80.23%	0.66
11	Suriname	-0.26%	-0.44%	-4.94%	5.18%	64.99%	0.64
12	Guatemala	-0.28%	-0.44%	-4.89%	5.78%	64.76%	0.64
13	Costa Rica	-0.42%	-0.56%	-4.76%	8.74%	56.90%	0.62
14	El Salvador	-0.28%	-0.42%	-4.60%	6.06%	64.07%	0.6
15	Canada	-0.59%	-0.68%	-4.45%	13.35%	46.47%	0.58
16	Peru	-0.16%	-0.27%	-4.24%	3.70%	73.62%	0.55
17	Zambia	-0.01%	-0.06%	-4.01%	0.25%	91.07%	0.52
18	Malaysia	-0.61%	-0.39%	-3.72%	16.42%	52.32%	0.49
19	China	-0.26%	-0.38%	-3.67%	7.17%	61.45%	0.48
20	Thailand	-0.28%	-0.38%	-3.56%	7.73%	60.70%	0.46
21	Philippines	-0.23%	-0.36%	-3.53%	6.43%	62.58%	0.46
22	Vietnam	-0.31%	-0.39%	-3.38%	9.30%	58.31%	0.44
23	Uruguay	-0.11%	-0.19%	-3.29%	3.31%	75.03%	0.43
24	Argentina	-0.06%	-0.13%	-3.28%	1.90%	81.66%	0.43
25	Indonesia	-0.11%	-0.19%	-2.99%	3.54%	73.39%	0.39
26	Colombia	-0.18%	-0.27%	-2.95%	5.97%	63.98%	0.39
27	Guyana	-0.37%	-0.41%	-2.95%	12.59%	50.22%	0.38
28	Chile	-0.14%	-0.23%	-2.89%	4.99%	67.64%	0.38

Table 3 (continued)

		Accumulated Effects (p.p. of own 2005 GDP)			% of Total Effect		
Rank	Country	1st.	2nd.	**Total**	1st.	5th./+	Elasticity
29	Rep. of Korea	-0.13%	-0.23%	-2.86%	4.66%	67.94%	0.37
30	Bolivia	-0.08%	-0.14%	-2.84%	2.64%	77.60%	0.37
31	Algeria	-0.24%	-0.32%	-2.74%	8.90%	57.04%	0.36
32	Mongolia	-0.17%	-0.28%	-2.65%	6.45%	60.28%	0.35
33	Israel	-0.30%	-0.35%	-2.59%	11.77%	51.16%	0.34
34	Madagascar	-0.15%	-0.22%	-2.51%	5.96%	65.87%	0.33
35	Malawi	-0.14%	-0.20%	-2.48%	5.53%	68.40%	0.32
36	Saudi Arabia	-0.22%	-0.26%	-2.47%	8.74%	60.56%	0.32
37	Sri Lanka	-0.21%	-0.28%	-2.42%	8.80%	57.62%	0.32
38	Yemen	-0.04%	-0.14%	-2.40%	1.83%	74.40%	0.31
39	St. Vinc. and Gr.	-0.08%	-0.17%	-2.38%	3.54%	70.66%	0.31
40	Oman	-0.04%	-0.16%	-2.37%	1.88%	72.77%	0.31
41	Ireland	-0.33%	-0.29%	-2.32%	14.26%	52.56%	0.3
42	Belize	-0.22%	-0.28%	-2.28%	9.48%	55.03%	0.3
43	Japan	-0.07%	-0.13%	-2.27%	3.16%	75.90%	0.3
44	Sudan	0.00%	-0.05%	-2.21%	0.06%	86.66%	0.29
45	St. Kitts and Nev.	-0.28%	-0.32%	-2.10%	13.30%	46.36%	0.27
46	Cte d'Ivoire	-0.17%	-0.23%	-2.06%	8.47%	58.97%	0.27
47	Jordan	-0.24%	-0.27%	-2.03%	11.80%	52.65%	0.26
48	Brazil	-0.08%	-0.13%	-1.99%	3.82%	72.84%	0.26
49	Switzerland	-0.08%	-0.14%	-1.81%	4.63%	69.24%	0.24
50	Qatar	-0.03%	-0.08%	-1.77%	1.51%	78.11%	0.23
51	Ukraine	-0.03%	-0.08%	-1.75%	1.87%	79.31%	0.23
52	Panama	-0.05%	-0.14%	-1.72%	3.02%	67.68%	0.22
53	Jamaica	-0.10%	-0.16%	-1.71%	5.70%	62.79%	0.22
54	Mauritania	0.00%	-0.04%	-1.64%	0.06%	85.00%	0.21
55	Pakistan	-0.06%	-0.10%	-1.63%	3.81%	74.20%	0.21
56	U. Arab Emirates	-0.03%	-0.09%	-1.62%	1.64%	76.33%	0.21
57	Malta	-0.12%	-0.16%	-1.60%	7.42%	61.46%	0.21

Table 3 (continued)

Rank	Country	Accumulated Effects (p.p. of own 2005 GDP)			% of Total Effect		Elasticity
		1st.	2nd.	**Total**	1st.	5th./+	
58	Cameroon	-0.02%	-0.05%	-1.59%	1.46%	83.59%	0.21
59	Rep. of Moldova	-0.04%	-0.08%	-1.57%	2.62%	77.26%	0.21
60	New Zealand	-0.07%	-0.12%	-1.52%	4.67%	69.54%	0.2
61	Germany	-0.07%	-0.12%	-1.49%	4.84%	69.07%	0.19
62	South Africa	-0.06%	-0.10%	-1.47%	3.93%	72.55%	0.19
63	Armenia	-0.02%	-0.05%	-1.43%	1.54%	82.95%	0.19
64	Egypt	-0.05%	-0.08%	-1.38%	3.66%	74.36%	0.18
65	Tanzania	-0.01%	-0.03%	-1.38%	0.47%	87.79%	0.18
66	Kazakhstan	-0.05%	-0.09%	-1.37%	3.42%	73.05%	0.18
67	Finland	-0.05%	-0.10%	-1.36%	3.92%	70.86%	0.18
68	Togo	-0.01%	-0.04%	-1.35%	0.59%	85.50%	0.18
69	Russian Fed.	-0.05%	-0.09%	-1.34%	3.63%	73.23%	0.17
70	Latvia	-0.06%	-0.09%	-1.32%	4.21%	71.00%	0.17
71	Sweden	-0.09%	-0.12%	-1.31%	7.01%	63.68%	0.17
72	Iran	0.00%	-0.03%	-1.30%	0.17%	85.53%	0.17
73	Belgium	-0.08%	-0.11%	-1.28%	6.51%	65.67%	0.17
74	India	-0.06%	-0.09%	-1.23%	4.60%	69.88%	0.16
75	Kiribati	-0.04%	-0.08%	-1.27%	3.15%	73.48%	0.17
76	Australia	-0.02%	-0.06%	-1.23%	1.95%	79.15%	0.16
77	Dominica	-0.03%	-0.09%	-1.23%	2.27%	70.06%	0.16
78	Paraguay	-0.02%	-0.05%	-1.22%	1.55%	80.42%	0.16
79	Norway	-0.06%	-0.10%	-1.21%	4.60%	67.18%	0.16
80	Estonia	-0.09%	-0.11%	-1.19%	7.72%	64.42%	0.16
81	Swaziland	-0.18%	-0.13%	-1.18%	14.88%	53.69%	0.15
82	Bahrain	-0.08%	-0.10%	-1.13%	6.96%	65.73%	0.15
83	Namibia	-0.05%	-0.08%	-1.14%	4.40%	70.05%	0.15
84	Fiji	-0.14%	-0.15%	-1.14%	12.68%	53.12%	0.15
85	Botswana	-0.05%	-0.08%	-1.14%	4.08%	70.82%	0.15
86	Austria	-0.05%	-0.08%	-1.11%	4.27%	70.78%	0.15

Table 3 (continued)

		Accumulated Effects (p.p. of own 2005 GDP)			% of Total Effect		
Rank	Country	1st.	2nd.	**Total**	1st.	5th./+	Elasticity
87	Belarus	-0.03%	-0.06%	-1.10%	2.64%	76.26%	0.14
88	Lithuania	-0.06%	-0.10%	-1.08%	5.68%	66.05%	0.14
89	Slovakia	-0.05%	-0.08%	-1.07%	4.53%	70.61%	0.14
90	United Kingdom	-0.05%	-0.09%	-1.06%	5.10%	67.12%	0.14
91	Netherlands	-0.06%	-0.09%	-1.06%	5.34%	67.37%	0.14
92	Saint Lucia	-0.09%	-0.12%	-1.06%	8.25%	58.19%	0.14
93	Central African Rep.	-0.01%	-0.02%	-1.06%	0.95%	88.29%	0.14
94	Italy	-0.04%	-0.07%	-1.05%	4.03%	72.07%	0.14
95	Mauritius	-0.09%	-0.11%	-1.05%	8.17%	61.92%	0.14
96	Hungary	-0.06%	-0.08%	-1.04%	5.29%	68.90%	0.14
97	Romania	-0.03%	-0.06%	-1.02%	3.00%	75.67%	0.13
98	Mozambique	0.00%	-0.03%	-1.02%	0.45%	83.76%	0.13
99	New Caledonia	-0.01%	-0.04%	-1.01%	1.35%	82.52%	0.13
100	Syrian Arab Rep.	-0.03%	-0.06%	-0.99%	2.95%	75.51%	0.13
101	Czech Republic	-0.04%	-0.07%	-0.98%	4.37%	70.44%	0.13
102	Bulgaria	-0.04%	-0.07%	-0.96%	4.43%	70.91%	0.13
103	Seychelles	-0.02%	-0.06%	-0.97%	1.98%	74.47%	0.13
104	France	-0.04%	-0.06%	-0.95%	3.97%	71.85%	0.12
105	Ghana	-0.04%	-0.07%	-0.95%	3.94%	71.10%	0.12
106	Benin	0.00%	-0.02%	-0.94%	0.03%	87.70%	0.12
107	Turkey	-0.04%	-0.06%	-0.93%	3.81%	72.87%	0.12
108	Denmark	-0.05%	-0.08%	-0.93%	5.09%	67.50%	0.12
109	Tunisia	-0.02%	-0.04%	-0.87%	2.23%	77.17%	0.11
110	Slovenia	-0.03%	-0.05%	-0.85%	3.38%	73.41%	0.11
111	Kyrgyzstan	0.00%	-0.04%	-0.85%	0.58%	79.18%	0.11
112	Hong Kong (China)	-0.12%	-0.07%	-0.83%	14.51%	56.01%	0.11
113	Morocco	-0.02%	-0.04%	-0.83%	2.22%	77.94%	0.11
114	Bosnia and Herz.	-0.02%	-0.04%	-0.83%	2.01%	79.49%	0.11
115	Burundi	-0.01%	-0.03%	-0.82%	1.70%	82.93%	0.11

Table 3 (continued)

		Accumulated Effects (p.p. of own 2005 GDP)			% of Total Effect		
Rank	Country	1st.	2nd.	**Total**	1st.	5th./+	Elasticity
116	Poland	-0.02%	-0.04%	-0.81%	1.94%	78.15%	0.11
117	Portugal	-0.03%	-0.05%	-0.80%	3.78%	73.02%	0.1
118	Iceland	-0.04%	-0.06%	-0.78%	5.20%	68.25%	0.1
119	Niger	-0.05%	-0.07%	-0.76%	6.25%	65.06%	0.1
120	Antigua and Barbuda	-0.01%	-0.04%	-0.74%	1.64%	75.20%	0.1
121	Georgia	-0.07%	-0.08%	-0.74%	10.00%	58.62%	0.1
122	Spain	-0.02%	-0.04%	-0.74%	2.53%	76.93%	0.1
123	Ethiopia	-0.01%	-0.03%	-0.64%	2.11%	79.46%	0.08
124	Azerbaijan	-0.01%	-0.03%	-0.60%	1.45%	78.98%	0.08
125	Barbados	-0.03%	-0.05%	-0.57%	4.42%	63.41%	0.07
126	Grenada	-0.04%	-0.05%	-0.56%	6.31%	62.38%	0.07
127	Senegal	0.00%	-0.01%	-0.54%	0.20%	87.12%	0.07
128	TFYR of Macedonia	-0.02%	-0.03%	-0.53%	3.75%	72.89%	0.07
129	Croatia	-0.02%	-0.04%	-0.53%	4.24%	72.53%	0.07
130	Maldives	-0.02%	-0.05%	-0.53%	3.33%	67.40%	0.07
131	Uganda	-0.01%	-0.02%	-0.51%	1.41%	85.09%	0.07
132	Luxembourg	-0.03%	-0.03%	-0.43%	5.98%	67.47%	0.06
133	Montserrat	-0.05%	-0.05%	-0.42%	12.00%	55.51%	0.06
134	Albania	-0.01%	-0.02%	-0.41%	2.59%	79.14%	0.05
135	Cook Islands	-0.03%	-0.04%	-0.41%	6.75%	63.16%	0.05
136	Greece	-0.01%	-0.02%	-0.34%	2.42%	79.41%	0.04
137	Turks and Caicos Is.	-0.04%	-0.05%	-0.33%	11.71%	50.95%	0.04
138	Sao Tome and Pr.	-0.01%	-0.02%	-0.33%	2.21%	72.38%	0.04
139	Cyprus	0.00%	-0.02%	-0.31%	1.42%	77.35%	0.04
140	French Polynesia	-0.03%	-0.03%	-0.27%	9.83%	57.47%	0.03
141	Gambia	0.00%	-0.01%	-0.27%	0.84%	80.48%	0.04
142	Cape Verde	-0.01%	-0.01%	-0.16%	4.08%	74.01%	0.02

Data Source: United Nations National Accounts Aggregates and COMTRADE.

Of the seven most important countries of South America in terms of GDP, six of them (Venezuela, Ecuador, Peru, Argentina, Colombia and Chile) belong to the group of the 30 most affected countries, with GDP elasticities ranging from 0.38 to 0.81. The remarkable exception is Brazil, which is in position 48 of the ranking. China is in position 19, with an overall impact of 3.67% of its 2005 GDP, experiencing a contraction close to half of the overall contraction of the US (elasticity of 0.48). In contrast, India is further away from the top (in position 74), with a total effect of 1.23%. The case of Japan is in between, its position being 43 (with an overall impact of 2.27%).

The most dynamic East Asian economies are dispersed. While Malaysia, Thailand and Republic of Korea are in positions 18, 20, and 29, respectively, Hong Kong (SAR of China), much less affected, stands 112[13]. A similar pattern is observed for the most important (as measured by GDP) African countries, Algeria, South Africa, Egypt, and Morocco (31, 62, 64 and 113, respectively).

Notwithstanding their importance in US direct import requirements (19.1% in 2005), European Union members are homogeneously located at the bottom of the table. The most affected EU member is Ireland, and its elasticity amounts to only 0.30. A possible explanation for the result obtained for the EU has to do with the crucial importance of intra-block trade, which accounts for 63.4% of the region's total imports in 2005.

The gains of working with a setup that intends to capture direct as well as indirect interdependences in foreign trade relations can be readily appreciated in the seventh column of the table, which displays the importance of the fifth and beyond rounds of multiplying effects on the total effect for each country. Of course, the US has the lowest ratio of the sample (29.4%).

The purpose of this exercise has been to emphasize the role of interdependence in the estimation of direct and indirect effects over all countries in the sample of a shock to the autonomous expenditures of only one economy, in this case, the US. It is the nature of multiplier mechanisms (through their feedback effects) that uncovers indirect relations among countries, which account for a very important part of the total repercussions of the shock. In this sense, to consider direct import requirements only or

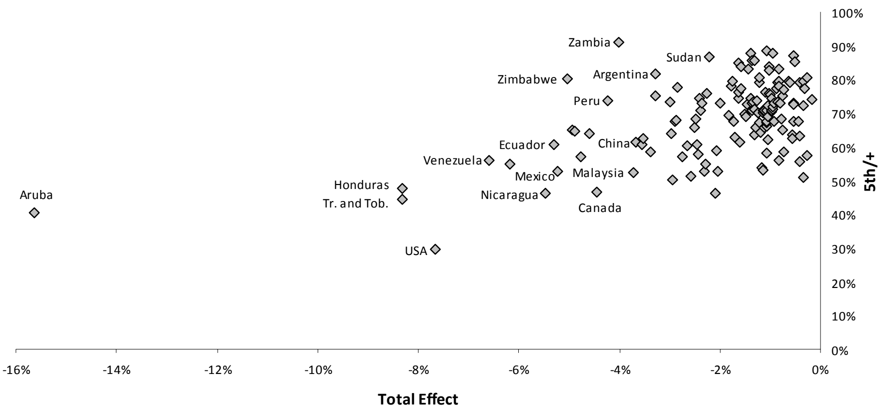
[13] When Singapore was included in the sample, the position of these countries in the ranking was 17, 21, 28 and 111, respectively, wich illustrates the lack of sensitivity of the final results to the exclusion of this country. The position of Singapore itself was 44.

formulate billateral partial equilibrium analyses might be misleading when assessing overall impacts.

Take, for example, the cases of Argentina and Brazil. These two neighbour countries belong to the MERCOSUR (Common Market of the South), a regional integration scheme that tightens direct foreign trade between them. However, their relative standing in the "vulnerability ranking" differs by 24 positions. While the elasticity to US GDP for Argentina is of 0.43, it is 40% lower in the case of Brazil (0.26). Even more, Argentina has one of the highest percentage of the total effect explianed by the 5th. and subsequent rounds (81.58%).

More generally, Figure 1 summarizes the gains of acknowledging interdependence. The horizontal axis measures the total fall in GDP (the vulnerability ranking builds up from this axis). On the other hand, the vertical axis measures the importance of the fifth and beyond rounds of indirect import requirements over the total GDP contraction for each country (seventh column of table 3). The positive slope one infers from the observation of the figure is what supports the widespread belief of countries being 'decoupled': the more indirect the relation, the weaker the impact of a shock. Note, however, the important facts that can be overlooked by such a naïve approach. Consider, for example, the cases of Canada and Peru. While Canada faces more immediate

Figure 1. Total effect and 5th+ rounds effects over Total effect



effects in the event of a US contraction, Peru appears to be more indirectly related to the latter economy. This notwithstanding, both Canada and Peru end up suffering the shock with similar intensity.

V. Relation to the Literature

As was already noted, the seminal paper to which our study can be methodologically related is Metzler's (1950) multiple-region theory of income and trade. Much in the spirit of Metzler, Goodwin (1980) proposed to use a world trade matrix to assess the multiplier effects of domestic demand an price shocks on the global economy, with special emphasis on the gains from transnational economic policy coordination. In a similar fashion, Weale (1984) constructs a world trade matrix for ten regions of the world in 1977 so as to evaluate the effects international aid. Johnson's note on the world trade multiplier Johnson (1956) also addresses the trade balance consequences of tranfers between countries, while Brown and Jones'(1962) article enlarges the original framework of Metzler by taking into consideration the distinction between goods and services used in current domestic production and consumption and goods designed to increase domestic capacity.

Taking the basic insight present in Metzler's article as a point of departure, there are many applied studies using different sources of data. At the sub-national level, Guccione and Gillen (1974) study the interdependences among regions in Canada. Sinclair and Sutcliffe (1988) present different methods for estimating income multipliers and then apply them to the Spanish province of Malaga. Olfert and Stabler (1999) study mutilplier effects at the community level. At the transnational level, Marwah (1976) divides the world into nine regions with the aim of understanding the transmission of an economic change in one country to all other countries through its effects on trade flows and through prices.

On the use of marginal propensities to import from different origins, a different approach to the one adopted in this paper can be found in Parikh (1988). The author proposes to take a country's imports as given, then assuming maximizing behaviour on the side of the importing country in order to allocate the total imports of the country among competing sources of supply.

The Input-Output framework developed by many authors within this literature has also been used to obtain integration measures among different economies, such as Doss and Cabalu's (2000) study on India's integration with the members of the Asia-Pacific Economic Cooperation (APEC), and Pal, Dietzenbacher and Basu's Pal et al.(2007) integration measures for the South Asian Association for Regional Cooperation (SAARC).

A more comprehensive model of contagion of a local crisis should incorporate not only the effects through international trade, but also the propagation mechanism that operates through the balance of payments as a whole. Cooper (1969) incorporates capital movements in a simple two-country model, with special concern on internationally coordinated policymaking.

As was already mentioned, the absence of supply considerations in the model used in this paper implies it is better suited to analyze contractions. In this sense, the literature on business cycle synchronization may get to tackle the problem with greater generality. At the empirical level, Rose (2008) surveys twenty studies that analyze the link between trade integration and output correlation[14]. Unfortunately, this literature accounts only for bilateral trade relations.

Recently, various studies emerged to address the growing concern about the possible impacts of an adjustment in the US economy. The seventy-ninth conference of the Brookings Panel on Economic Activity discussed the position of the US in the global economy in depth. Among the articles presented, compiled in the Brookings Papers on Economic Activiy 2005:1, Blanchard, Giavazzi and Sa (Blanchard et al.,2005) propose a model that not only contemplates movements in the capital accounts, but also allows for exchange rate adjustments. This enables the authors to conclude that adjustments in the US external position is likely to take place with an exchange rate depreciation. Also at the 2005 Brookings Panel, Obstfeld and Rogoff (2005) emphasize the likely implications of a US current account adjustment on global exchange rates, stressing the potential risks of such an adjustment on general economic stability.

Aiyar and Tchakarov (2008) study the potential implications of a downturn in the US economic performance on Thailand, in light of the fact that the US is Thailand's largest export destination. Employing a set of four structural equations, and estimating its parameters with Bayesian techniques, the authors

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[14] Burstein, Kurz and Tesar (2008), not included in Rose's survey, study the enhanced business cycle synchronization for countries engaged in a vertically integrated production network.

find that a 1 percent slowdown in US economic growth in 2008 could have an upper-bound impact on Thailand's GDP growth of as much as 0.9 percentage points. Compared to the estimates of our model, this is a relatively high figure, although Thailand's position in the vulnerability ranking of the previous section is rather high.

This time is, of course, not the first time in history that an adjustment in a large economy has nontrivial effects for the rest of the world. In what may be considered the reciprocal framework of Blanchard et al.(2005) and Obstfeld and Rogoff (2005), Branson (1972) proposed to assess the effects on trade of the early 1970's currency realignments. In the context of the Asian crisis of the late 1990's, Abeysinghe and Forbes (2001) developed a structural VAR approach to the problem of identifying both direct and indirect trade linkages through which a shock to a single country may propagate to the rest of the world. Applying the model to Asia and the US, they conclude that indirect effects are non-negligible relative to the importance of the effects captured by only considering bilateral, instead of multilateral, trade linkages.

VI. Concluding Remarks

With the aim of assessing the transmission of a local crisis to the world economy, we developed a simple representation of the global economy that enabled us to consider the interdependences observed in the world trade matrix. After discussing an appropriate identification strategy for the parameters of the model, the empirical exercise of a negative shock to the US autonomous expenditures was carried out as an appealing example in the current international context. This allowed us to construct a "vulnerability ranking" to a downturn in the US economy for the 142 countries considered.

The results cast serious doubts on the 'decoupling' hypothesis when the 2005 trade pattern is considered. Many 'emerging market' economies stand very high in the vulnerability ranking of Table 3, especially Latin America (excluding Brazil), China, Malaysia, Thailand and Republic of Korea. Notably, it is EU economies that appear to be relatively armoured against the transmission of a shock to the US economy through international trade.

The simplicity of the model proposed to account for such a complex problem has its counterpart in the aforementioned drawbacks, such as the potential instability of our estimates of the marginal propensities to spend and import, and the heroical assumptions regarding prices and exchange rates.

Nonetheless, we hope that the results are useful for policy analysis. For instance, macroeconomic policies require considering the vulnerability of individual economies to the stance of the global economy.

The interpretation of the exercise that we want to emphasize is its usefulness for sound policymaking. In the face of increasing integration of international markets, it is necessary to develop tools that enable a proper consideration of the vulnerabilities individual economies might be exposed to. Partial equilibrium frameworks may be misleading for decision makers. We do not claim our framework complies with the requirements of a fully-specified general equilibrium model. Actually, the 2005 data on international trade and national accounts used in this study are likely to be describing an out-of-equilibrium situation, as was thoroughly argumented at the seventy-ninth conference of the Brookings Panel on Economic Activity. However, our exercise does aim at capturing interdependences in a unified framework, even if only by considering commodity trade relations.

In contradistinction, we would like to stress what we do **not** mean with this paper. Economic integration has positive effects for the countries involved, as has been documented by the literature. A wrong interpretation of the results of section IV may lead to the conclusion that independence from the rest of the world, and therefore little participation in international trade, is the best strategy to follow, since it guarantees a bottom-position in any vulnerability ranking. In contrast, we sustain that the gains from economic integration far outweigh its potential risks. Taking those risks into account when fiscal, monetary and industrial policies are conducted is a means of minimizing the costs of integration, thereby maximizing its net gains.

Regarding further research in the direction proposed by our analysis, it would be interesting to use the United Nations data at a more disaggregate level, considering world transactions matrices for each of the 10 reported digits of the SITC Rev. 3 classification. Different levels of autonomous imports might be considered for different types of commodities. On the other hand, in the particular case of imports, a more comprehensive demand function, encompassing the use of imports as an input for producing exports, could improve important aspects of our proposal, specifically when the comparative statics exercise is seen as the result of a multiplying process.

More generally, the most challenging task for future research is to incorporate price, exchange rate and trade pattern movements as endogenous responses to exogenous impulses. Regarding marginal propensities estimates, the linear model we used might be replaced by a nonparametric estimation of the relation between expenditures and income. Although closed form solutions are likely to be less easily obtainable, some interesting results could emerge from the analysis of the structural form of such a model.

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Appendix

Here we shall prove that, under Condition 1, (17) translates into (18) as $n \to \infty$. It is evident that, under Condition 1, the limit of the left-hand side of equation (17) as $n \to \infty$ is $\mathbf{Y}$.

Consider now the right-hand side of the equation. At any given stage of the recursive substitution procedure proposed in (16), we can calculate

$$(\mathbf{I} + \mathbf{H} + \mathbf{H}^2 + \ldots + \mathbf{H}^{n-1})(\mathbf{I} - \mathbf{H}) \tag{24}$$

It is straightforward to see that the terms in (24) cancel out so as to obtain

$$\mathbf{I} - \mathbf{H}^n \tag{25}$$

Note that, provided condition 1 holds, the limit of (25) as $n \to \infty$ is $\mathbf{I}$. This same result is achieved when the right-hand side of equation (17) is *pre-multiplied* by$(\mathbf{I} - \mathbf{H})$. Hence, condition 1 is sufficient for

$$\lim_{n \to \infty}(\mathbf{I} + \mathbf{H} + \mathbf{H}^2 + \ldots + \mathbf{H}^{n-1}) = (\mathbf{I} - \mathbf{H})^{-1}$$

Thus, the limit of the right-hand side of (17) as $n \to \infty$ equals $(\mathbf{I} - \mathbf{H})^{-1}\mathbf{A}$, which completes the proof.